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Research & Development

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APRIL 1984

Labcon West '84 show issue

News of value to people who work in R&D

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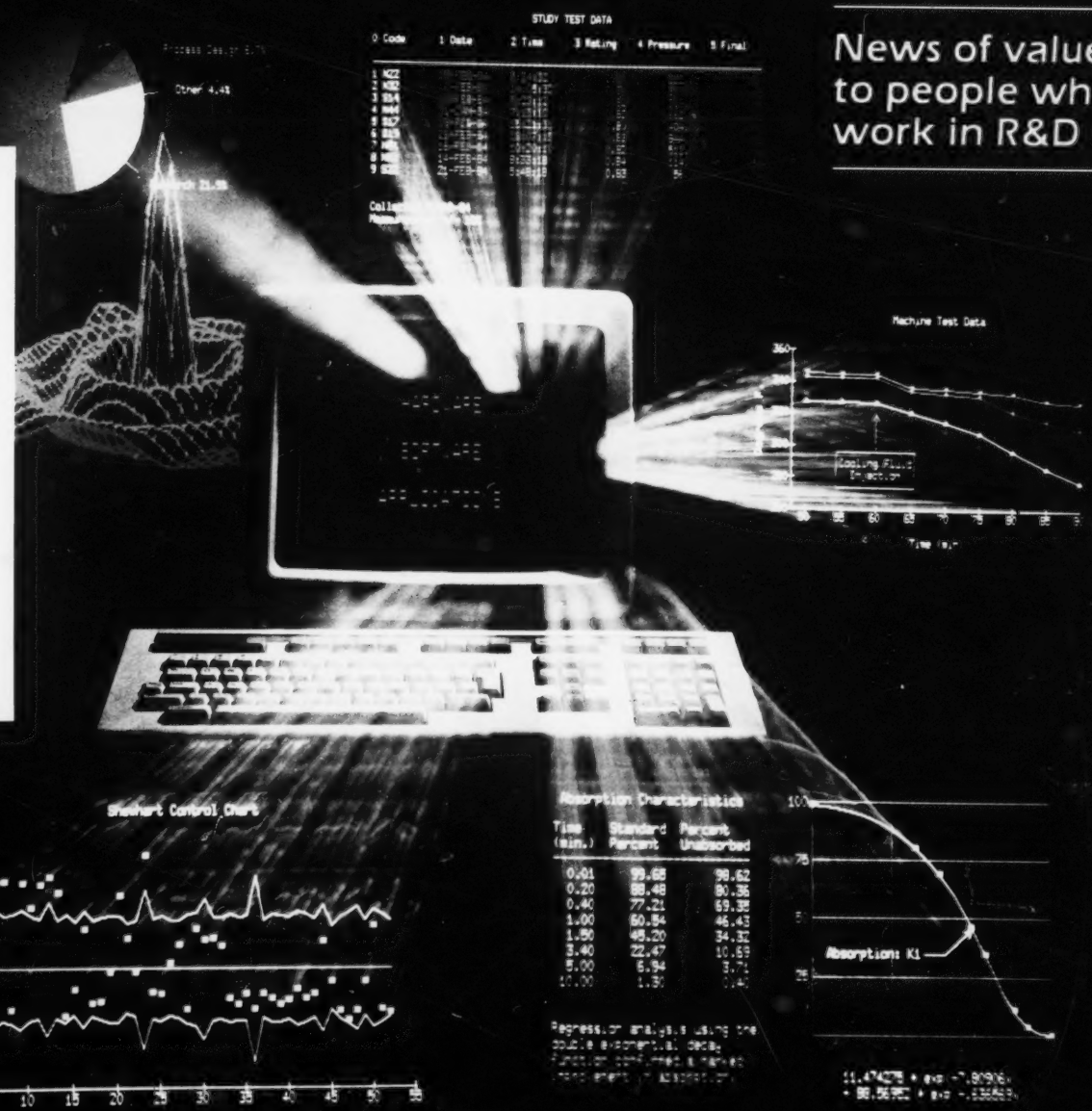

Research & Development

SERVING THE $186-BILLION WORLDWIDE R&D INDUSTRY

Software for R&D labs. See p 94.

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ABOUT THE COVER

The advent of computer software designed specifically for the handling of research-generated data has given to scientists and engineers a powerful tool for speeding their work and for avoiding systematic errors.

Graphics packages allow the user to view and to present data in various ways to improve understanding of lab results. Statistics packages aid the user in analysis of the information and in the prediction of results from future experiments.

The cover, from BBN Software Products Corp., Cambridge, MA, was produced for this issue by photographer Steve Grohe.

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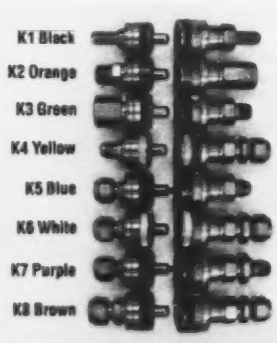

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OPINION POLL RESULTS

R&D workers continue love affair with personal computer

SEVENTY-EIGHT percent of the workers in research, development, and quality assurance have regular access to at least one personal computer, if the more than 2,400 respondents to our recent survey on this subject are typical of the industry.

In asking this question and others that are discussed below, we defined a PC as "having I/O capability, having performance between that of programmable handheld calculators and of the true desktop computers, and costing less than $5,000."

Software is a problem for many of the respondents, and 83% say they write some or all of the software for their work. Data processing is the largest single category of PC application for our readers, and data acquisition is the third largest. Together, they make up 48% of the PC applications.

Second-largest use of PCs by our respondents was for word processing, it being the primary use for one in every eight respondents. While this heavy word-processing activity might be taken as an indication that "publish or perish" continues to be a real threat in many fields, it should be pointed out that word processing provides substantial advantages for report writing, especially when a program combines data- and word-processing activities.

Of the respondents who do not have regular access to a PC (22%), 56% expect to have such access soon. However, this should not be taken to indicate that the remainder will lack regular access to the advantages of computing. Many of those will not get a PC because they have regular access to a desktop, a mini, or a mainframe.

Looking at the responses by disciplines, data processing is the primary application for a PC for 52% of the responding ceramists, 49% of the biologists, and 44% of the aeronautical engineers. Data processing is the primary application for only 20% of the electrical engineers who list CAD/CAE, word processing, and equipment/process control as other important applications for them.

When it comes to peripherals, the combination of disk drive, CRT display, dot-matrix printer, and telephone modem is used by 54% of the ceramists, 49% of the metallurgists, 46% of the physicists, and 45% of the electrical engineers.

Letter-quality printers are used by 31% of the industrial engineers, 25% of the mathematicians, and 27% of the "others."

Complete results of this survey, by discipline, appear on the opposite page.

CIRCLE 260 ON INQUIRY CARD

Percent of respondents by disciplines

	Chemist	Chemical engr.	Mechanical engr.	Electrical engr.	Aeronautical engr.	Industrial engr.	Physicist	Metallurgist	Biologist	Mathematician	Ceramist	Geologist	Other	All respondents
1. Do you have regular access to a personal computer?														
a. Yes, at work	33	37	26	27	19	22	32	37	40	35	31	35	31	32
b. Yes, at home	17	19	23	20	29	16	18	18	8	17	7	27	14	17
c. Yes, both	28	18	25	38	26	36	36	21	33	35	31	15	31	29
d. No	22	26	27	15	26	26	14	24	19	13	31	23	24	22
(If yes, go to No. 3.)														
2. Do you expect to have regular access to one soon?														
a. Yes, at work	24	27	33	23	57	33	26	23	36	33	11	0	27	26
b. Yes, at home	20	18	7	30	0	17	31	14	18	0	11	33	14	18
c. Yes, both	9	8	13	12	14	25	6	9	14	0	22	17	23	12
d. No	47	47	45	35	29	25	37	54	32	67	56	50	37	43
(If yes, go to No. 7. If no, go to No. 9 to list your discipline.)														
3. Do you plan to acquire another one soon?														
a. Yes, same brand and model	8	6	5	4	11	16	8	3	8	11	10	10	8	7
b. Yes, same brand, more powerful	14	19	17	23	16	25	5	16	16	21	15	5	15	17
c. Another brand	21	20	23	24	5	28	27	25	25	26	10	20	25	23
d. No	57	55	55	49	68	31	50	56	51	42	65	65	52	53
4. Do you have a PC that is conveniently portable?														
a. Yes	28	20	34	33	20	48	30	22	27	30	35	50	25	29
b. No	72	80	66	67	80	52	70	78	73	70	65	50	75	71
5. Is available software adequate for your needs?														
a. Yes	58	59	61	63	65	58	61	58	58	55	70	50	61	60
b. No	42	41	39	37	35	42	39	42	42	45	30	50	39	40
6. Do you write your own software?														
a. Yes, all	8	11	12	16	15	15	18	12	8	35	15	5	10	11
b. Yes, some of it	73	75	71	72	80	82	76	70	58	60	75	85	66	72
c. No	19	14	17	12	5	3	6	18	34	5	10	10	24	17
7. Do you use (or plan to use) a PC primarily for . . .														
a. Data processing	39	36	27	20	44	22	28	33	49	43	52	39	33	34
b. Electronic filing	7	4	6	9	0	2	3	5	3	0	0	0	7	6
c. Financial management	5	8	7	6	9	15	5	8	5	0	9	9	4	6
d. Education	9	8	9	9	4	5	11	14	4	10	4	22	9	9
e. Data acquisition	13	8	15	7	0	12	17	19	12	5	17	9	10	12
f. Word processing	14	15	13	17	26	28	19	10	17	10	13	13	19	16
g. CAD/CAE	1	4	12	11	4	2	2	0	1	10	0	4	4	4
h. Equipment/process control	7	8	6	13	0	12	6	8	5	5	0	4	6	7
i. Other	5	9	5	7	13	2	9	3	4	19	4	0	8	6
8. Do you have now or plan to acquire soon . . .														
a. Disk drive	6	4	8	7	8	3	6	9	5	5	4	9	3	6
b. Cassette drive	3	4	6	3	4	0	3	1	4	0	4	9	5	4
c. CRT display	2	3	3	1	4	0	3	3	1	0	8	0	1	2
d. Dot-matrix printer	3	1	2	1	8	0	3	1	2	10	0	4	3	2
e. Letter-quality printer	3	4	1	3	0	5	3	1	3	5	4	4	5	3
f. Telephone modem	3	1	2	6	0	5	3	3	6	15	0	4	6	4
g. a + c + d	33	32	33	30	24	30	37	43	27	20	46	35	27	32
h. a + c + e	11	13	13	9	12	23	8	9	15	20	0	13	17	12
i. g + f	12	11	4	15	4	10	9	6	10	25	8	4	12	11
j. h + f	4	6	2	6	8	3	5	1	8	0	4	4	5	5
k. Other	9	6	9	6	12	3	9	5	7	0	0	0	6	7
l. None	11	15	17	13	16	18	11	18	11	0	21	13	9	12

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The 1984 Laboratory of the Year

Recent advances in industrial biotechnology

Our unique R&D news section

Research & Development

SERVING THE $186-BILLION WORLDWIDE R&D INDUSTRY

Integrated facility reflects R&D activity in High Honors lab. See p 92.

EDITORIAL

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ABOUT THE COVER

We proudly present to you the 1984 *Research & Development* Laboratory of the Year. We congratulate the architects, scientists, and planners responsible for the design of the Warner-Lambert Consumer Products R&D Center in Morris Plains, NJ.

The Lab of the Year judges also cited for High Honors the Chevron Research Laboratory Building E and the Westvaco Forest Science Laboratory.

An article describing these and other well-designed labs begins on p 92.

NEWS

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72 Conferences: Expanded program is planned for Labcon Central

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Special Report—Space Development

79 Obstacles fall as Reagan pushes hard for space station; Europe considers its space options; ESA lobbies to lower price of shuttle service; NASA becomes more ambitious in satellite retrieval; plans are set for ocean drilling project

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102 Recovering a product—the last hurdle in the bioprocessing race: E.S. Lipinsky, B.R. Allen, D.M. Jenkins, L.M. Curran, Battelle; economic feasibility depends on product recovery.

106 DNA synthesizers provide 'catalyst' for genetic research gains: R.M. Cook, Biosearch Inc.; automated gene machines eliminate the tedium in making nucleotides.

112 Industry pulls ahead of government in R&D median salaries: R.R. Jones, editor; career premium for PhD degree tops $600,000; low wages for women in academia.

118 Old and new problems are solved by polymers containing graphite: B.M. Vanderbilt and F.R. Chipps, R.E. Darling Co.; graphite improves properties of thermoset polybutadiene.

125 Optical emission can end your etch process on time, every time: Gene Scott, Xinix Inc.; spectroscopy technique provides reliable endpoint control of semiconductor production.

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Robert R. Jones
Editor

Industry pulls ahead of government in R&D median salaries

Career premium for PhD degree averages more than $600,000, but doctoral women working in universities get far less.

THE VALUE of an advanced degree is obvious in research, development, and quality assurance. As was mentioned in the preceding article (in our March issue), the net value of a PhD over a BS depends on an individual's field of endeavor and sex, and whether the employer is from industry, academia, or government.

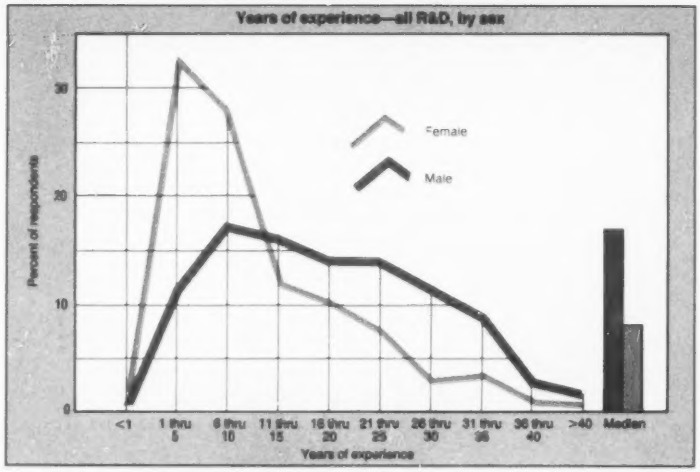
For the average of the PhD-holders among this year's more than 4,200 respondents, the net value of a PhD over a BS in a 25-year career is nearly $620,000. That is what remains after deducting for costs of the added education and allowing for the additional years spent in school.

We assume that the holder of the PhD will work approximately 25 years after getting that degree, as our survey shows is typical. We allow a 30-year career for the person who enters the work force after getting a BS. Assuming a 10% interest rate prevailing over the 25-year career of the PhD and allowing $300,000 for tuition, missed earnings, etc., we then can make appropriate projections.

The value of a PhD over an MS is more than $370,000; and for a PhD over less than a BS it is $875,000.

Getting a BS is a good investment. The net benefit of a BS over less than BS is more than $255,000. Adding the MS is worth an additional $250,000 over a 25-year career.

For our respondents as a whole, median salaries by highest academic degree are compared in this table:

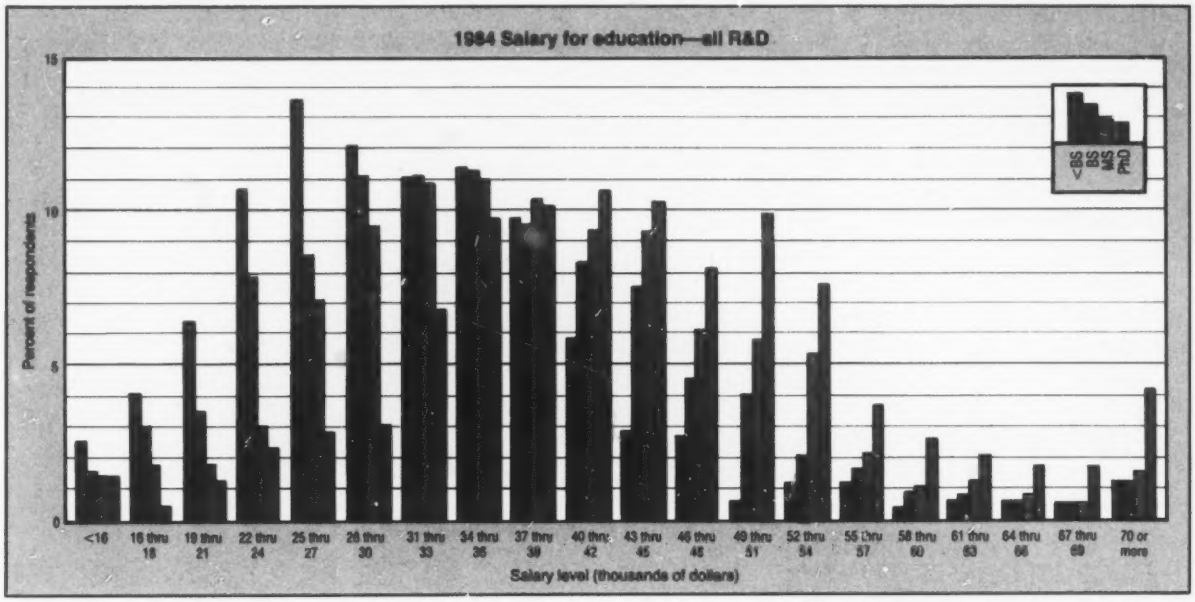


Salaries compared by academic degrees

Degree	Median salary 1984	Median salary 1983	Percent change	Annual difference* 1984	Annual difference* 1983	Difference increase%
Doctorate	$43,200	$40,590	+6.4	$5,280	$4,310	+22.5
Master	37,920	36,200	+4.5	3,210	3,100	+3.5
Bachelor	34,710	33,180	+4.6	3,760	5,100	−26.3
<Bachelor	30,950	27,670	+11.8			

*Difference above next-lower degree

As was true a year ago, the income advantages of baccalaureate and advanced degrees are increasing faster than inflation. The advantage in annual income for a PhD over less than bachelor this year is $12,250, down from $12,920 last year, but still well above the $9,990 spread of three



years ago.

The advantage of a PhD over a BS now is $8,500 per year, compared to $7,400 last year and $7,250 two years ago.

As with any averages, much additional information is needed to make the situation clear. Women who work in research, development, and quality assurance earn a lot less than men do, but that is not to say they always earn less for equal work. For many reasons the female work force cannot be compared directly with the male counterparts.

Because of differences in opportunities, women almost always have less experience than men in R&D and QA. They usually have less time with their present employers. And they usually have less education. Thus, the higher paying jobs tend to be occupied by males with advanced degrees and substantial work experience.

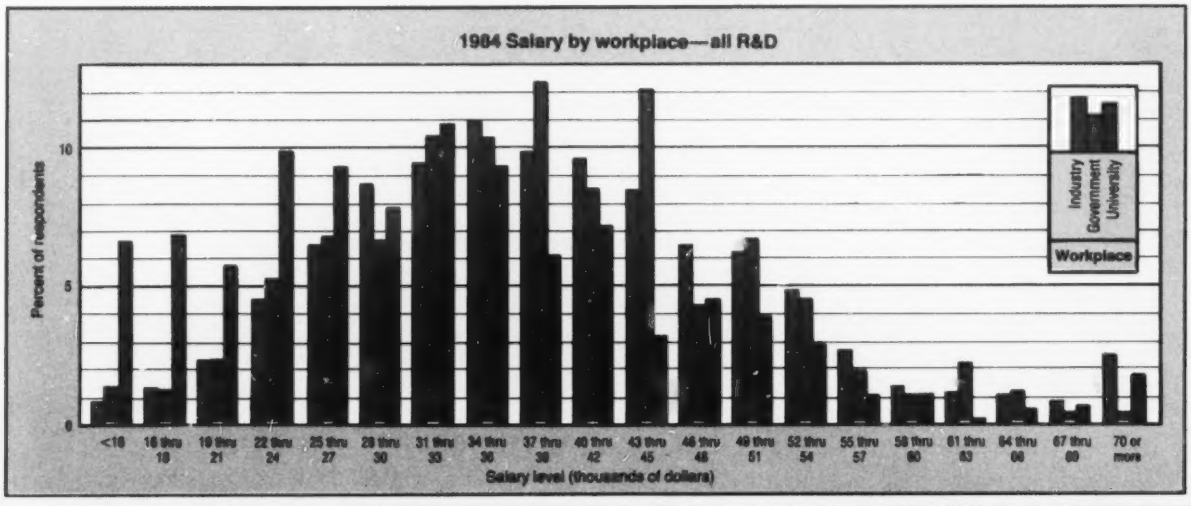
When all of the differences are brought to bear, we find that the male R&D worker in industry is earning a median annual salary of $39,200 in contrast to the female R&D worker in a university where her median annual salary is $20,450.

Looking at salaries for workers in R&D and QA by sex and work place, we find important differences from government to industry to university. One important change here is that government has recently relinquished some of its traditional salary leadership to industry.

Another is the male-female salary difference mentioned above, leading to the fact that the lowest male median still exceeds the highest female median. The ranking is as follows:

Men in industry	$39,200
Men in government	38,630
Men in universities	32,580
Women in industry	29,590
Women in government	29,450
Women in universities	20,450

In this year's survey, the median annual income for all males is $38,440 and for



all females it is $28,990.

That old idea that "Uncle Sugar" pays the best wages is hard to stomp out. Over the years this survey has tended to support that idea. But no more. Compare the differences in 1980 and 1984 medians for all workers by work place:

	1980	1984
Government	$29,733	$38,210
Industry	28,354	38,550
University	25,685	31,890

You might point out, in response to the above, that there are proportionately more women working in the universities, a fact which would pull the university medians down. But don't forget, there are proportionately more PhDs in the universities, and that should help to pull the salaries back up—but, obviously, not back up to the level of industry.

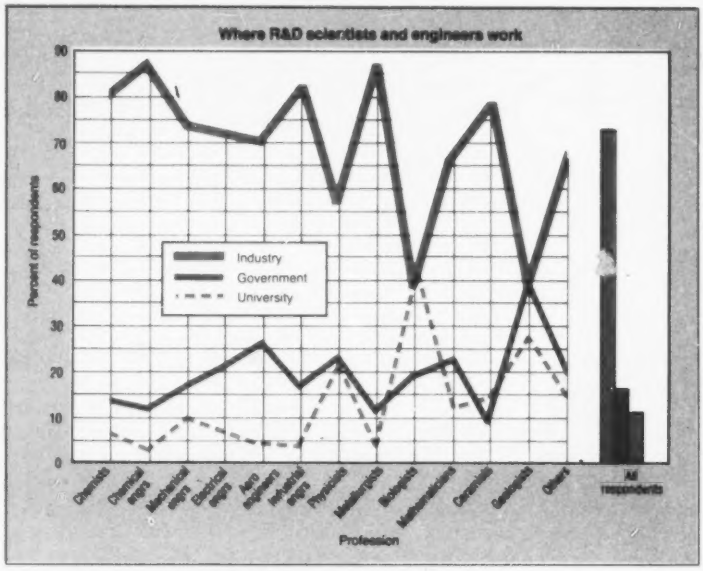
When it comes to salary increases, women did as well (or as poorly) as men at the low end of the scale last year. For both sexes, 18.3% received salary increases of less than 2%. At the upper end, women did substantially better than men, with nearly a third more getting increases of 10% or more.

Salary increases by sex

	1983 %		1982 %	
Amount	Male	Female	Male	Female
None	16.3	15.6	14.8	12.9
Less than 2%	2.0	2.7	1.9	1.1
2 thru 5%	27.3	20.5	15.8	17.7
6 thru 9%	38.9	39.5	34.2	33.4
10 thru 13%	11.2	15.6	25.2	23.1
14% or more	4.3	6.1	8.1	11.8

Some 37.7% of the women respondents are earning $31,000 per year or more, up from 34.9% last year and 25% two years ago. But, as would be expected, men dominate the upper brackets, with 75.7% of the male respondents earning more than $31,000 per year, up from 71.3% last year and 63.0% two years ago.

Our chart shows that women in R&D



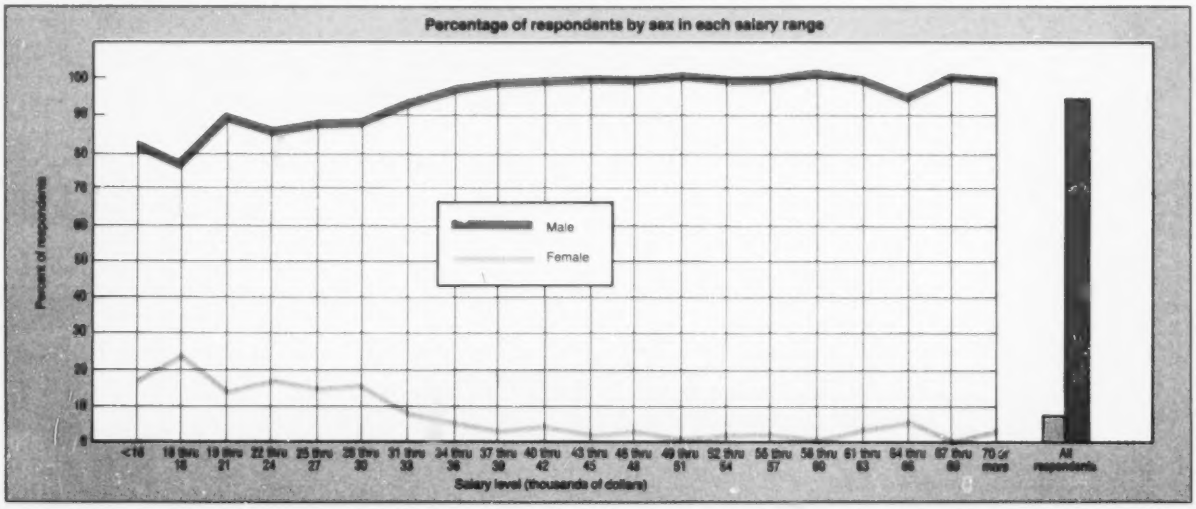
and QA continue to lag far behind men in work experience, certainly to no one's surprise. Median years of experience for males in R&D is 16.73 years, virtually unchanged for the past several years. For women, the median is 7.86 years, little changed from earlier reports.

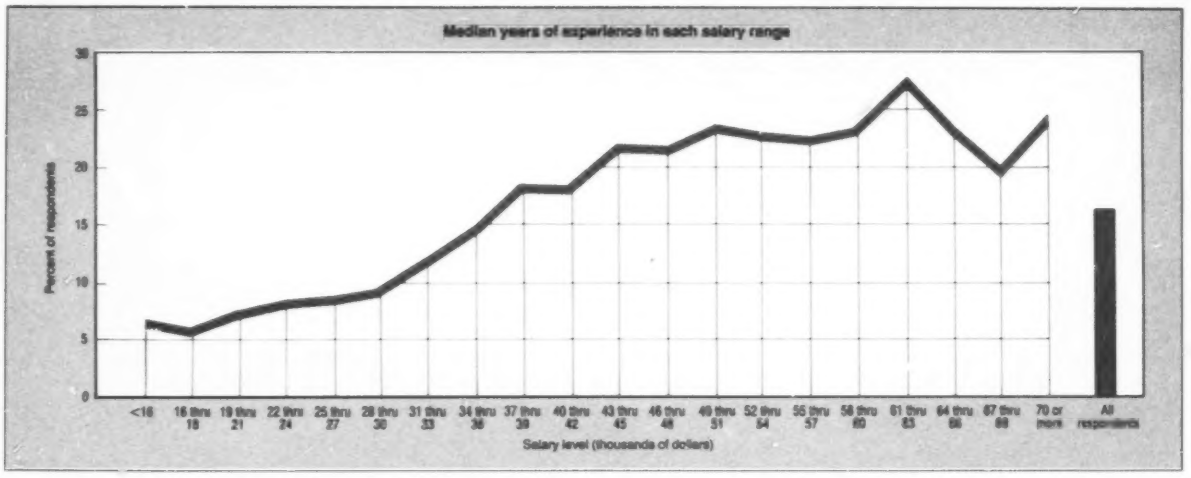
A full 40.0% of the male respondents report having more than 20 years' experience, up slightly from recent years. Less than half that percentage, or 15.5%, of the female respondents report having 20 years' experience in their present work, up from a year ago and in line with earlier reports.

At the low end of experience, 34.2% of the female respondents have less than six years' experience in their present work, compared to 12.2% for the men.

One factor limiting women's work experience is that only recently have significant numbers been moving into the work force. While 74.7% of the women are younger than 40 years of age, only 45.0% of the men are that young.

This is reflected in the fact that many





women have not had an opportunity to earn an advanced degree. The percentage of women in this year's respondents who have a PhD is down from a year ago at 14.8 and in line with earlier years. This year's male respondents are in line with previous years at 31.9% PhD.

Longevity, time with the same company, always is a factor in salary. The fact that 4.2% of the male respondents have been with their present employers for more than 30 years helps to explain their higher position on the salary scale. Only 2.0% of the women have the same longevity.

Women with fewer than seven years in the same firm make up 60.8% of the female respondents, up slightly from recent years. Only 38.7% of the males have been with their present employer for less than seven years.

Much additional information about the people who work in research, development, and quality assurance is provided in the accompanying charts and tables.

Following are complete results of the Opinion Poll Survey:

1984 R&D Salary Survey Results

1. What is your annual salary?

a. Less than $16,000	1.6%
b. $16,000 to $18,999	2.0
c. $19,000 to $21,999	2.6
d. $22,000 to $24,999	5.1
e. $25,000 to $27,999	6.9
f. $28,000 to $30,999	8.3
g. $31,000 to $33,999	9.9
h. $34,000 to $36,999	10.8
i. $37,000 to $39,999	10.0
j. $40,000 to $42,999	9.2
k. $43,000 to $45,999	8.6
m. $46,000 to $48,999	6.0
n. $49,000 to $51,999	6.1
o. $52,000 to $54,999	4.7
p. $55,000 to $57,999	2.4
r. $58,000 to $60,999	1.4
s. $61,000 to $63,999	1.4
t. $64,000 to $66,999	0.9
u. $67,000 to $69,999	0.3
w. $70,000 or more	1.0

2. Your raise during the past year was ...

a. None	10.3%
b. Less than 2%	2.1
c. 2 thru 5%	26.9
d. 6 thru 9%	38.9
e. 10 thru 13%	11.5
f. 14% or more	4.4

3. How long have your worked for your present employer?

a. Less than 1 year	4.2%
b. 1 thru 3 years	17.5
c. 4 thru 6 years	18.3
d. 7 thru 9 years	11.8
e. 10 thru 12 years	8.9
f. 13 thru 15 years	7.6
g. 16 thru 18 years	8.6
h. 19 thru 21 years	6.4
i. 22 thru 24 years	5.3
j. 25 thru 27 years	4.4
k. 28 thru 30 years	2.9
m. 31 thru 33 years	2.4
n. 34 thru 36 years	0.8
o. More than 36 years	0.9

4. What is your age?

a. Under 26	2.7%
b. 26 thru 30	11.2
c. 31 thru 35	16.0
d. 36 thru 40	16.8
e. 41 thru 45	15.6
f. 46 thru 50	12.2
g. 51 thru 55	11.9
h. 56 thru 60	8.3
i. 61 thru 65	3.9
j. Over 65	1.1

5. How many years of experience do you have?

a. Less than 1 year	0.5%
b. 1 thru 5 years	13.1
c. 6 thru 10 years	17.8
d. 11 thru 15 years	16.0
e. 16 thru 20 years	13.9
f. 21 thru 25 years	13.5
g. 26 thru 30 years	11.4
h. 31 thru 35 years	8.8
i. 36 thru 40 years	2.8
j. More than 40 years	2.0

6. What is the highest degree you hold?

a. Less than bachelor	7.3%
b. Bachelor	36.5
c. Master	25.5
d. Doctorate	30.8

7. What is your profession?

a. Chemist	37.8%
b. Chemical engineer	6.6
c. Mechanical engineer	9.6
d. Electrical engineer	10.3
e. Aeronautical engineer	1.2
f. Industrial engineer	1.3
g. Physicist	8.6
h. Metallurgist	5.3
i. Biolgist	5.4
j. Mathematician	0.6
k. Ceramist	1.6
m. Geologist	1.2
n. Other	10.6

8. Do you work in ....

a. Industry	72.8%
b. Government	16.6
c. University	10.6

9. Are you ....

a. Male	93.7%
b. Female	6.3

R&D

OPINION POLL RESULTS

Technology should assist, not replace, older industry

THE SO-CALLED smokestack industries should be retained and high technology should help them to modernize, say the nearly 2,000 respondents to our recent poll on this subject.

The poll followed an Editorial in which we quoted Ian M. Ross of Bell Labs and Roland W. Schmitt of GE on the subjects of reviving the present industries *vs* replacing them and on the seriousness of foreign competition.

Readers were nearly unanimous (96%) in agreement with Ross about the application of technology to the solution of industry's woes. Complete results of the survey follow.

1. *Do you believe that we need to retain the so-called smokestack industries in some form?*
   a. Yes ... 89% b. No ... 7% c. No opinion ... 4%

2. *Do you agree with Ross that we need to use high technology to upgrade the basic industries?*
   a. Yes ... 96% b. No ... 3% c. No opinion ... 1%

3. *Would it "be economically healthier for states and municipalities to try to upgrade present industry than to try to attract high technology?"*
   a. Yes ..... 23% b. Yes, usually 9%
   c. Rarely ..... 62 d. No. 6

4. *Ross says that upgrading any state's economy will depend on "improving the educational system which must supply its most important resource—creative and skilled people." Do you agree?*
   a. Yes ... 91% b. No ... 7% c. No opinion ... 2%

5. *He declares that improving education will require "a national movement that is effected at the state and local level by a people who understand the importance of education." Do you agree?*
   a. Yes ... 88% b. No ... 9% c. No opinion ... 3%

6. *In the same Editorial, Schmitt is quoted, "The Japanese ... are competent, skillful, aggressive competitors who win commercial victories with the same armaments that are available to us." Do you agree?*
   a. Yes ... 74% b. No .. 22% c. No opinion ... 5%

7. *And Schmitt adds, "In many ways our strengths are greater than theirs," citing our entrepreneurial climate, our free market system, and research universities. Do you agree?*
   a. Yes ... 75% b. No .. 17% c. No opinion . 8%

8. *Do you study such subjects as these ...*
   a. Regularly 23% b. Fairly often 61% c. No 16%

9. *What is your principal resource?*
   a. Newspapers . 21% b. Magazines 68%
   c. Books ..... 7 d. Television 2
   e. Speakers ..... 1 f. Friends 1

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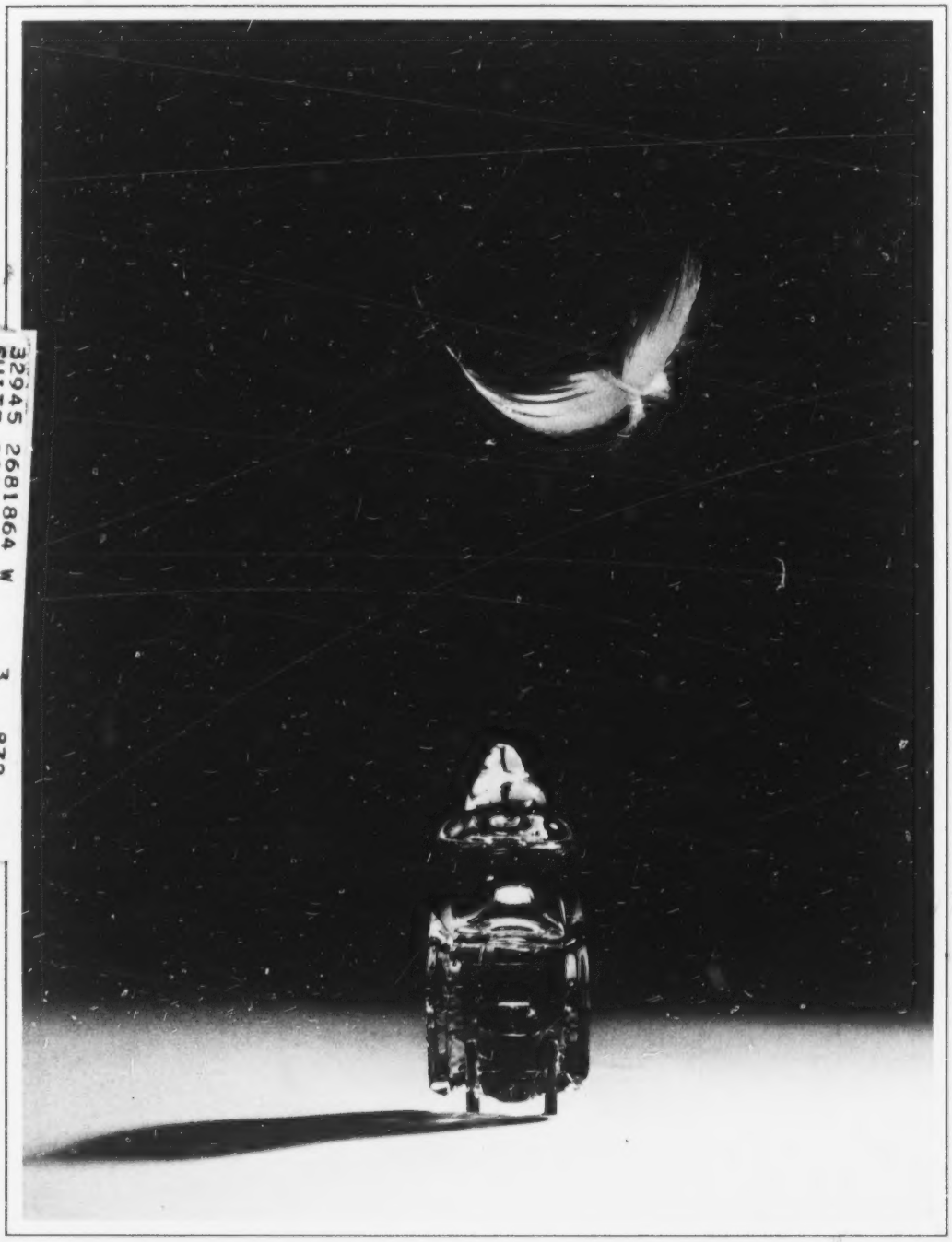

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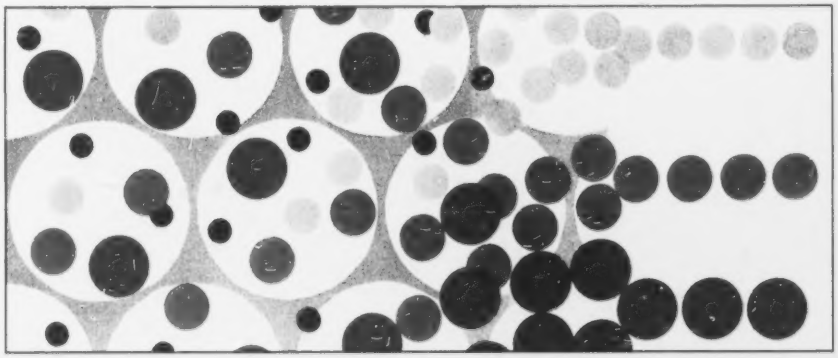

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ABOUT THE COVER

The most efficient use of space in modern analytical instruments has required the development of smaller and smaller light sources and—frequently—lower voltages. At the same time, the small sources have to retain high and constant illumination.

One answer to this problem is a subminiature halogen lamp from Gilway Technical Lamp, Woburn, MA. Although this 6-V lamp is only 8.5 mm dia., it develops a color temperature of 3200 K while consuming only 1.6 A. The lamp sells for less than $5 (feather not included).

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OPINION POLL RESULTS

Shuttle, spacelab hold important potential for R&D

THE SCIENTISTS and engineers who read this magazine see important applications for research which could be done in space. And, four out of every five of them would go into space to do the research. That is true if the nearly 1,900 respondents to our recent survey on this subject are representative of our readers.

More than half of the respondents believe that there could be at least a little advantage to their research from present shuttle programs. Nearly a fourth of the respondents expect a lot of advantage.

Looking at the possibility of introducing new programs to the shuttle flights, 71% of the respondents believe that their research might benefit. Included in that figure are 26% who believe that more than one research program could be done in space to advance their special needs, and 14% say that there are many such programs as far as their work is concerned.

Complete results of the survey follow:

1. *Do you see any potential advantages for your research from present shuttle programs?*
   a. A lot ..... 23% c. Doubtful 20%
   b. A little ..... 33 d. No 23

2. *Are there space research programs that could be done on the shuttle that would be helpful to your research?*
   a. Yes, many ..... 14% c. Perhaps 31%
   b. Yes, a few ..... 26 d. Probably not 29

3. *Does materials processing in a weightless environment hold any potential for your research?*
   a. Yes .... 21% b. Possibly ... 35% c. No ... 45%

4. *Do life sciences tests in weightlessness hold any potential for your research?*
   a. Yes .... 10% b. Possibly ... 24% c. No ... 66%

5. *Does research above Earth's atmosphere have potential for your studies?*
   a. Yes .... 23% b. Possibly ... 35% c. No ... 42%

6. *Does exposure to cosmic rays or continuous insolation have advantages for your research?*
   a. Yes .... 12% b. Possibly ... 27% c. No ... 61%

7. *Could your field of research be advanced significantly by having a scientist at work on a space station?*
   a. Yes ..... 16% c. Possibly 35%
   b. Probably ..... 16 d. No 33

8. *If you were given the opportunity, would you fly in the space shuttle to pursue your research?*
   a. Yes ..... 52% c. No 23%
   b. Probably ..... 17 d. No way! 8

9. *If you were given the opportunity, would you work in a space station to pursue your research?*
   a. Wow! Would I! ... 53% c. No 21%
   b. If necessary 26

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